Flight Opportunities Program
Office of the Chief Technologist

Parabolic Flight Campaign October 2012

Campaign Dates: September 27 – October 5, 2012
Total payloads: 6
Parabolas: Zero G

#	Title	PI/Organization
1	Iso-grid, Thermal-Structural Panel (IsoTherm)	Hans-Peter Dumm Air Force Research Laboratory/Space Vehicles Directorate
2	Activity Monitoring during Parabolic Flight	Peter Cavanagh University of Washington
3	Sintering of Composite Materials Under Reduced Gravity Conditions	Orazio Chiarenza Advanced Technical Institute, Italy
4	Evaporative Heat Transfer Mechanisms within a Heat Melt Compactor (EHeM HMC) Experiment	Eric Golliher NASA Glenn Research Center
5	Parabolic Flight Evaluation of a Hermetic Surgery System for Reduced Gravity	George Pantalos University of Louisville
6	Non-Invasive Hemodynamic Monitoring in Microgravity	Gregory Kovacs Stanford University

Iso-grid, Thermal-Structural Panel (IsoTherm)

Problem Statement

- New satellite thermal management technologies are needed to reduce non-recurring costs and enable advanced technologies to be incorporated on modern spacecraft
- The iso-grid, thermal-structural panel (IsoTherm) represents a one size-fits-most solution for satellite thermal control, but it's microgravity performance needs to be better understood
- Potential users are NASA, DoD, and commercial space companies

Technology Development Team

- PI: Greg Busch, Air Force Research Laboratory/Space Vehicles Directorate, greg.busch@kirtland.af.mil
- AFRL/RVSV
  3550 Aberdeen Ave SE
  Kirtland AFB, NM 87117
- NASA Goddard Space Center

Proposed Flight Experiment

Experiment Readiness:

- September 2012.

Test Vehicles:

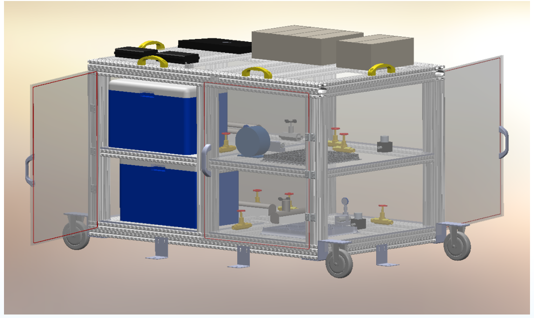
- Zero Gravity Corporation Boeing 727-200

Test Environment:

- The experiment has not flown in any previous micro-gravity flights. The flight environment requested is short duration micro-gravity to characterize pump performance.

Test Apparatus Description:

- The experiment consists of single-phase and 2-phase flow loops. Each loop will be installed on a shelf inside of a liquid-tight experiment cart (for secondary containment), shown below. Ice baths in water-tight coolers will be used to remove heat generated during the testing, and the electrical interface with the aircraft is 115 VAC single-phase.



Technology Maturation

- Microgravity and on-orbit performance characterization needed to mature to TRL 6
- Steps to Mature:
  - Characterize the pump performance in microgravity, Sep 2012
  - Integrate pumps into panel and ground-test, 2013
  - Characterize the on-orbit performance, 2016
- No deadline to mature to TRL 6

Objective of Proposed Experiment

- Characterize the micro-gravity performance of the Iso-Therm panel with specific emphasis on the electro-hydrodynamic (EHD) pump approach
- The experiment will generate pump pressure generation and flow rate data. Combined with measurements of the power power draw, these data can be used to characterize pump performance

TA14: Thermal Management Systems. TA12: Materials, Structures, Mechanical Systems and Manufacturing

Activity Monitoring for Parabolic Flight

Problem Statement

- Bone loss due to microgravity may have serious consequences during and after long-duration space flight missions. This project offers a non-invasive predictive approach to the monitoring and maintenance of bone health during space missions.
- This flight will validate our activity monitoring system, tri-axial accelerometers with Bluetooth wireless communication, in microgravity.
- Potential users of the matured technology include NASA health personnel, exercise specialists, the aging population, osteoporotic patients and elderly care personnel.

Technology Development Team

- Peter Cavanagh, PhD, PI
  Department of Orthopaedics and Sports Medicine, University of Washington
  cavanagh@uw.edu

- Funded by National Space Biomedical Research Institute
  BioScience Research Collaborative
  6500 Main Street, Suite 910
  Houston, TX 77030-1402
  (713) 798-7412
- Partners in technology development:
  NASA Glenn Research Center,
  ZIN Technologies

Proposed Flight Experiment

Experiment Readiness:

- The experiment will be ready for flight by September 2012.

Test Vehicles:

- Parabolic aircraft (Boeing 727)

Test Environment:

- The sensor hardware has flown briefly on a Zero G Corporation parabolic aircraft. The system performed well during a single proof-of-concept test. We have been approved through Flight Opportunities, to perform testing of our experiment using a Boeing 727 or similar aircraft during parabolic flight.

Test Apparatus Description:

- Small sensors will be worn on the test subject's ankle and mid-lower back during exercises performed on a treadmill. The sensor, an example attachment site, and the treadmill setup can be seen below.

Technology Maturation

- The system is currently at a TRL of 5. The system components are well-integrated and the technology has been thoroughly tested in a simulated environment using the enhanced Zero-G locomotion simulator at NASA Glenn.
- The deadline, to mature the technology to TRL 6 or higher is December 31, 2012 based on NSBRI funding.
- Testing during parabolic flight will move the TRL forward to 7, allowing demonstration in an operational environment. Testing during parabolic flight is anticipated in October 2012.

Objective of Proposed Experiment

- The main goal for this parabolic flight is to simulate as many activities as possible which could occur on the International Space Station on a daily basis (both exercise and activities of daily living) for activity recognition and bone health monitoring purposes.
- The data retrieved from this experiment will give us the necessary acceleration/force relationships needed for skeletal loading predictions. The data will also verify our activity recognition algorithms in a zero-g environment.

List the applicable Technology Areas addressed by your technology: TA06 Human Health, Life Support and Habitation Systems

SINTERING OF COMPOSITE MATERIALS UNDER REDUCED GRAVITY CONDITIONS

Problem Statement

- The experiment's technology addresses NASA OCT Areas 7 & 12, by demonstrating how the sintering process in reduced gravity can produce high quality materials needed for human settlements on the Moon, and for special ground applications,
- The flight opportunity will provide the reduced gravity conditions needed by the process to obtain highly uniform micro-structures of the sintered materials, starting from sedimentation-free powders.
- Potential users of the technology may be International Space Agencies and private Commercial Organizations and Companies.

Objective of Proposed Experiment

- Objectives of the parabolic flight campaign is to process some pre-compacted samples of simulated lunar soil powders, to be compared with composite materials obtained in 1-g using the same process.
- Expected results are that samples processed at reduced gravity will show a better particle spread and agglomeration, which will improve their thermal & mechanical characteristics.

Proposed Flight Experiment

Test Apparatus Description:

- The test apparatus consists of an induction heater furnace, capable of processing pre-compressed composite material samples in a vacuum chamber according to computer-controlled temperature cycles. Two operators are required for monitoring the cycles and replacing the samples in the chamber.

Experiment Readiness:

- The experiment is ready for flight. The hardware's construction was completed in 2010, and all components and assemblies have been fully tested in 1-g conditions for safety and functionality.

Test Vehicle and Environment:

- The Flight Opportunities' vehicle required for the experiment is the parabolic flight aircraft.
- The experiment hardware has never flown before. In order to test the technology for application to space exploration, the preferred reduced gravity environment is the "lunar" gravity. Additional tests in micro-gravity and "Martian" gravity can be useful as well.

Technology Maturation

- For the current status of its hardware, the experiment has been assessed at TRL 6. The furnace can be considered as a high fidelity prototype of the one intended for materials processing in space.
- Results from the parabolic flights may advance the maturity of the technology to the following levels, involving the construction of a fully automated machine capable of extracting and processing the lunar soil, in order to produce locally the materials to be used by human settlements on the Moon.

Technology Development Team

- Principal Investigator: Dr. Carmelo Mandarino, Advanced Technical Institute "E. Fermi", 87024 Fuscaldo, Cosenza, Italy, e-mail: cmandarino@tiscali.it

- The experiment was developed for the COSMIC Project of the Italian Space Agency (ASI), Viale Liegi, 26, 00198 Rome, Italy.
- No organization that may become partner in this technology development has been identified yet. Cooperation for future developments will be proposed to NASA & ASI after the flight.

Evaporative Heat Transfer Mechanisms within a Heat Melt Compactor Experiment

Problem Statement

- Evaporative heat transfer involves both fluid movement and heat transfer. First, we need to know the microgravity fluid physics of the drying process for the proposed Heat Melt Compactor. Later, based on that data, we can refine math models for overall heat transfer and effect good hardware design.
- A parabolic aircraft flight opportunity will provide test data to show fluid movement
- Heat Melt Compactor, Advanced Clothing Systems.

Technology Development Team

- Eric Golliher, NASA GRC, Eric.L.Golliher@nasa.gov
- Heat Melt Compactor Technical Lead, John Fischer, John.W.Fischer@nasa.gov
- Logistics Reduction and Repurposing, James Broyan, James.L.Broyan@nasa.gov

Proposed Flight Experiment

Experiment Readiness:

- Ready Date is September 2012.

Test Vehicles:

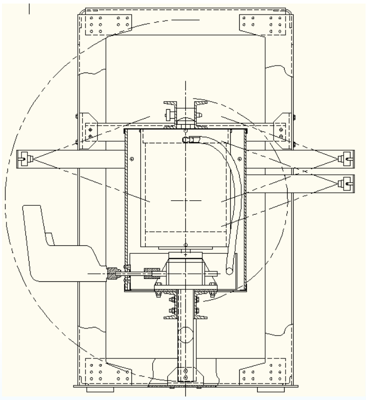
- Parabolic Aircraft

Test Environment:

- No previous microgravity testing

Test Apparatus Description:

- A clear circular test section, doubly contained within a Vertical Equipment Rack that is viewed by three cameras, is filled with simulated trash and water. A ordinary electric hand drill drives a screw that compacts the wet trash to discover when water will be expelled based on varying: 1) compaction rates, and 2) water mass fractions



Technology Maturation

- TRL 6 is accomplished by a series of microgravity tests, the last of which is the operational test aboard the ISS Express Rack in 2018.
- October 2012 – The first microgravity test is called the Water Expulsion Test (WET)
- Summer 2013 and later – Anti Carryover Test (ACT), Thermal Diffusivity Test (TDT), Isothermal Brine bag Evaluation Test (IBET)

Objective of Proposed Experiment

- Water Expulsion Test (WET) will determine if both liquid and air, or only air, is expelled during microgravity operation
- The flight video data will be reviewed and digitized to measure the amount of liquid expelled during microgravity operation

TA06, Human Health, Life Support and Habitation Systems & TA14, Thermal Management Systems

Parabolic Flight Evaluation of a Hermetic Surgery System for Reduced Gravity

Problem Statement

- Technology Problem: Currently no apparatus exists to perform surgery in space. There are no methods for isolating the surgical cavity nor managing bleeding.
- Importance: Critical technology to handle trauma/emergencies during long duration space missions
- Flight opportunity allows us to test early prototypes of a surgical system that will isolate the wound to prevent cabin contamination, facilitate hemostasis, and aid in surgical field visualization.
- Potential users: Astronaut physicians

Technology Development Team

- George M. Pantalos, Ph.D.; Professor of Surgery and Bioengineering at University of Louisville; gmpant02@louisville.edu
- James F. Antaki, Ph.D.; Professor of Biomedical Engineering at Carnegie Mellon University; Antaki@andrew.cmu.edu
- To be determined.

Proposed Flight Experiment

Experiment Readiness:

- September 2012

Test Vehicles:

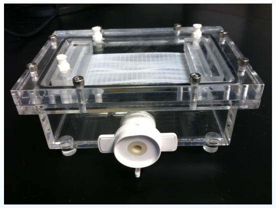
- Parabolic aircraft

Test Environment:

- Previous flight environment: None
- Requested environment through FOP: zero gravity, lunar-g, Martian-g

Test Apparatus Description:

The developmental models of the HeSS to be evaluated are affixed to the top of the instrumentation chassis with the operators positioned on each side foot-strapped to the floor of the aircraft. On the top of the instrumentation chassis is a sealed chamber with multiple ports to evaluate chamber pressurization of surgical structures and surgical instrument insertion that have been part of the HeSS development pathway.



Technology Maturation

- Current TRL: 4
- TRL 5: Fall 2012 flight campaign will evaluate prototype in relevant flight environment.
- TRL 6: Fall 2012 flight campaign will provide early subsystem evaluation in relevant environment in anticipation of system integration
- Fall 2012: Initial evaluation of subsystem prototype in relevant flight environment; Winter/Spring 2013: Development of near final version of technology; Summer/Fall 2013: Parabolic flight campaign evaluation of near final version to achieve TRL 6; Winter/Spring 2014: Development of final prototype; Summer/Fall 2014: Final parabolic evaluation to achieve TRL 7
- TRL 6 deadline: Fall 2013

Objective of Proposed Experiment

- Objective 1: Observe prototype hydrodynamics in relevant environment
- Objective 2: Given the hydrodynamics may be different in microgravity, determine optimal placement of suction instrument to remove blood from surgical field
- Objective 3: Demonstrate feasibility of surgically repairing tissue in an aqueous environment in reduced gravity conditions

Technology Area 06: Human Health, Life Support, and Habitation Systems

Non-Invasive Hemodynamic Monitoring in Microgravity

Problem Statement

- Hemodynamic monitoring is of prime importance for assessing cardiovascular changes due to fluid shifts and reduced loading in space. Current technologies (echocardiography, ICG) remain complex for routine use. Therefore, a ballistocardiography (BCG)-based system is being developed.
- The BCG system is suited for both terrestrial and space use. Testing in reduced gravity will provide vital information to relate future micro-gravity measurements to existing ground studies.
- NASA, for preventive monitoring, and titration of counter-measures in space. Healthcare providers, for ground-based non-invasive hemodynamic monitoring.

Technology Development Team

PI: Prof. Gregory T. A. Kovacs, M.D., Ph.D.
Stanford University
E-mail: kovacs@cis.Stanford.edu

Support: Self-funded, with support from Stanford University.

Proposed Flight Experiment

Experiment Readiness:

- 09/27/2012

Test Vehicles:

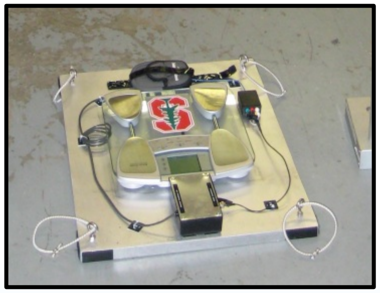
- Parabolic aircraft

Test Environment:

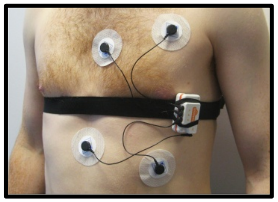
- Experiment will require microgravity (0g) environment..

Test Apparatus Description:

- The BCG system is composed of a weighing scale and accelerometer (for noise cancellation) attached to the airframe. A set of electrodes and an accelerometer is attached to the test subject to record the electrocardiogram (ECG) and the acceleration BCG. Data will be streamed to a laptop for visualization, as well as logged locally.
- Measurements will be taken with the test subjects tethered to the scale, as well as free-floating.



Scale on its base, with signal conditioning electronics.



Shimmer data logger & ECG (accelerometer not shown. ECG may be separate).

Technology Maturation

This flight campaign is expected to lead to the following maturation steps:

- Successful recording of scale-based BCG in microgravity.
- Successful collection of ground and microgravity BCG measurements on the same device.
- Validation of the relationship between ground-based and microgravity-based measurements.

A new device at TRL 6 could be validated in a 2013 flight campaign.

Objective of Proposed Experiment

- Demonstrate scale-based BCG recordings in microgravity.
- Refine noise-cancellation algorithms for high-quality BCG recording in microgravity.
- Gather BCG measurements in 1 and 0g using the same device, allowing interpretation of micro-gravity data in light of ground studies.
- Collect free-floating acceleration BCG data, for comparison with existing microgravity BCG data.

Applicable to TA-06 (Human Health, Life Support & Habitation Systems) - Human Health and Performance